

Coal to Nuclear Considerations

Montana Legislature
Energy and Telecommunications
Interim Committee

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Coal Plant Closure – Devastating Impacts

- Two coal plants closed on the same day in rural Adams County, Ohio
- *The closing of those plants meant the loss of more than 700 jobs and devastation to the local economy.*
- *“That money is never coming back,” Ty Pell [president of the county commissioners] said of the millions of dollars in salaries and tax revenue*
- *The county commission has slashed the budget two years in a row in anticipation of lean times ahead*
- *Workers fled for jobs in Wyoming, Florida, Washington, Idaho, Wisconsin, Colorado, Oregon, and elsewhere.*
- *The local school system has seen enrollment plunge and has cut positions to make up for budget shortfalls*

Source: Washington Post, “In small towns across the nation, the death of a coal plant leaves an unmistakable void,” 2019

System Benefits of SMRs

- Fuel diversity
 - Lowest cost systems have fuel diversity
 - Long term price stability
- Reliable dispatchable generation
 - 24/7, 365 days per year, years between refueling
 - Capacity factors of 95% or more
- Integration with renewables and storage
 - Paired with heat storage and able to quickly change power
- Carbon-free generation
 - Zero-carbon emissions, one of the lowest total carbon footprints
- Resilience for mission critical activities
 - Black-start capability and able to operate independent from the grid
 - Protect against natural phenomena, cyber threats and electro-magnetic pulses
- Use existing transmission infrastructure

Economic Benefits of SMRs

■ Employment

- 900 manufacturing and construction jobs over 4 years (average)
- 300 permanent positions during 60+ years of operation
- Multiplier effect: additional 1.66 jobs in local economy, 2.36 rest of the state
- Nuclear jobs pay 20% more, on average, than jobs at other energy sources
- Nuclear jobs pay 36% more than average salaries in local area

■ Economic Activity

- \$500M+ in direct and indirect economic output annually
 - ◆ \$270 million in electricity sales
 - ◆ Spending at local (\$10M), State (\$48M) and national (\$236M) level
- Taxes: \$10M in state and local, and \$40M in federal annually

Advanced Reactors Offer Significant Well-Paying Jobs

| Generation Type | Permanent Jobs on Site ¹ | Industry Wage Median | Carbon Free? | Firm Energy? | Benefits Concentrated Locally? |
|-------------------|-------------------------------------|----------------------|--------------|--------------|--------------------------------|
| Nuclear | 237* | \$41.32 | Yes | Yes | Yes |
| Coal ² | 107 | \$33.64 | No | Yes | Yes |
| Natural Gas | 30 | \$34.02 | No | Yes | Yes |
| Wind | 80 | \$25.95 | Yes | No | No |
| Solar | 36 | \$24.48 | Yes | No | No |

1) Comparison of alternatives producing annual electricity output equivalent to a typical 1,000 MWe coal plant

2) Only jobs at coal plant, does not include jobs associated with coal mining

Source: Scott Madden, *Gone with the Steam*

Similar Jobs and Limited Retraining

| Coal Plant Position | # Dedicated Coal Positions | SMR Position | # Dedicated SMR Positions | Position Type | Degree of Retraining Required |
|---------------------------------|----------------------------|-------------------------|---------------------------|---|-------------------------------|
| Operations Supervisor | 5 | Senior Reactor Operator | 5 | Supervisor | High |
| Control Room Operator | 10 | Reactor Operator | 15 | Operator | High |
| Field Operator | 15 | Non-Licensed Operator | 25 | Operator | Low |
| Lab Operator/Chemistry/Scrubber | 4 | Chem Tech | 14 | Craft | Medium |
| Maintenance Supervisor | 2 | Maintenance Supervisor | 3 | Supervisor | Medium |
| Mechanical Craft | 12 | Mechanical Craft | 21 | Craft | Low |
| I&C Craft | 9 | I&C Craft | 10 | Craft | Medium |
| Electrician Craft | 5 | Electrician Craft | 11 | Craft | Low |
| Technician | 11 | Technician | 13 | Laborer | Low |
| Security Officer | 20 | Security Officer | 48 | Laborer | Low |
| Sub-Total | 93 | | 165 | | |
| All Other Positions | 14 | | 72 | 42 are O&M Support (Planners, Outage, etc.) | Medium |
| Total On-Site Positions | 107 | | 237 | | |
| Possible Centralized Positions | | | 33 | | |
| Total Positions | | | 270 | | |

SMRs Are Environmentally Friendly

- Air Quality
 - Zero-carbon emissions, one of the lowest total carbon footprint
 - No emissions of SO_x, NO_x or other air pollutants
- Water Use
 - Many SMRs are being designed with ability for dry air cooling
 - Would enable SMRs to be located where water is scarce or expensive
- Land Use (per 1,000 MWe)

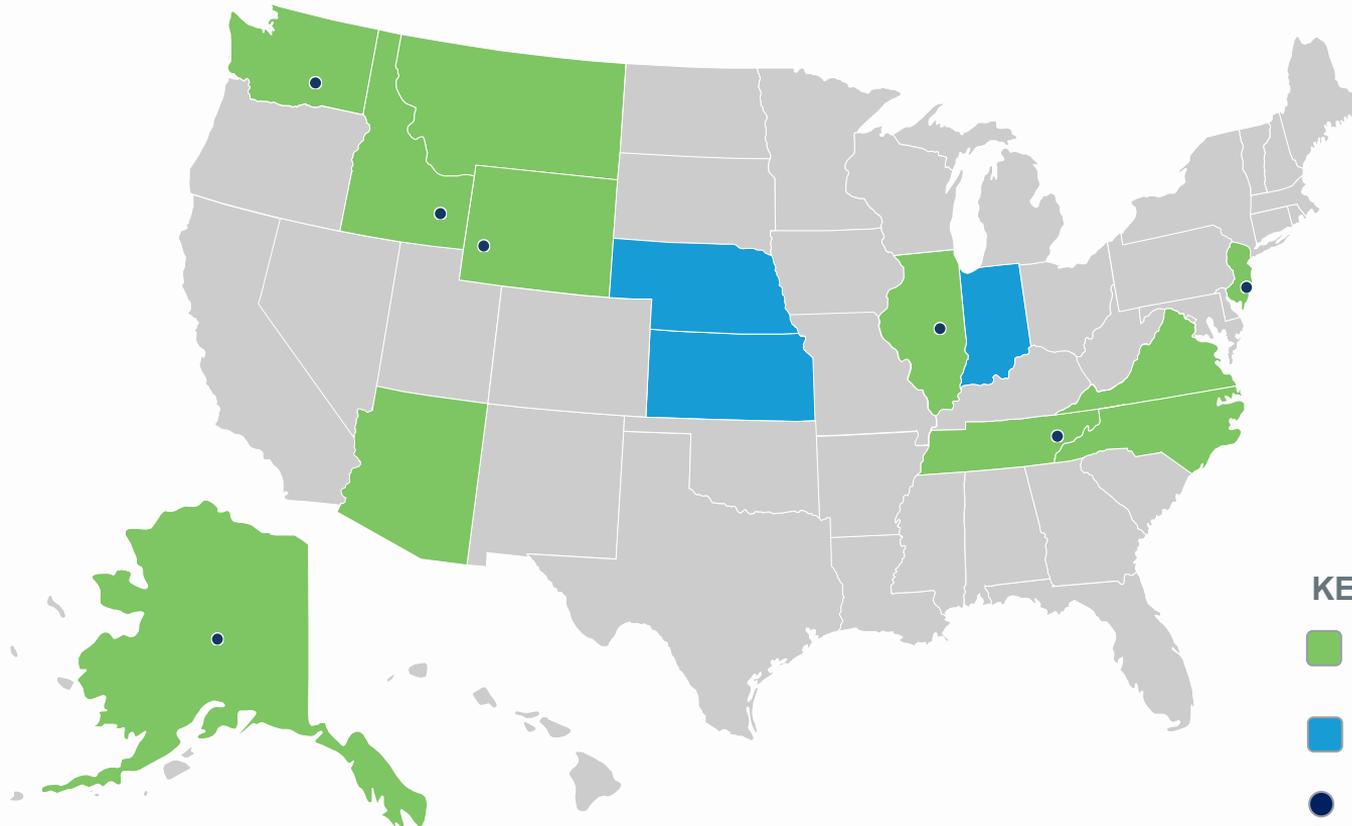
| | SMR | NGCC | Wind | Solar |
|---|------------------|------------------|-------------|--------------|
| Capacity factor (%) ¹² | 95 | 55 ¹³ | 35 | 25 |
| Plant life (years) | 60 to 80 | 40 to 50 | 20 to 25 | 20 to 25 |
| Lifetime TWh | 647 | 241 | 76 | 55 |
| Land required (acres) ^{14, 15, 16} | 50 ¹⁷ | 343 | 85,240 | 7,900 |
| Land Utilization (acres per Lifetime TWh) | <0.1 | 1.4 | 1,125 | 144 |

Utility and State Interest in SMRs

| State | Legislative Action | Utility Action |
|----------------|--|---|
| Alaska | Bills introduced to repeal voter approval to site | Eielson AFB site for first micro-reactor for DoD |
| Arizona | Clean energy standard under development | Utility interest in 25 MWe of UAMPS/NuScale |
| Idaho | Tax incentives passed | Host of UAMPS/NuScale SMR |
| Montana | Passed bill to study coal to SMR Repealed voter approval to site | Consideration of replacing Colstrip with nuclear |
| Nebraska | Passed bill on SMR tax incentives | Broad support for SMRs in state |
| North Carolina | Passed decarbonization plan bill | Duke Energy includes SMRs in IRP |
| Virginia | Nuclear Energy Strategic Plan Clean energy standard including nuclear | Dominion includes SMRs in IRP |
| Washington | Clean energy standard including nuclear | Energy Northwest with X-energy demo Grant County PUD MOU with X-energy and NuScale |
| Wyoming | Passed bill calling for coal retirements to be replaced with SMRs | Rocky Mt. Power siting for TerraPower demo |

Advanced Nuclear Deployment Plans

More than 20 projects in planning or under consideration in U.S. and Canada



KEY

-  Advanced Reactor is being planned or considered
-  Interest or policies to support advanced reactors
-  Planned project

Policy Support for Coal Communities

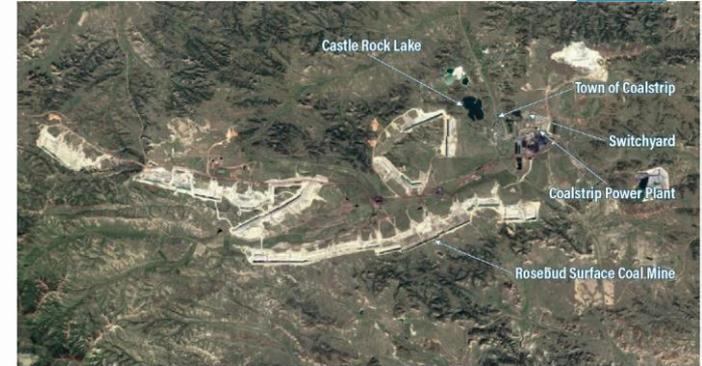
- E.O. 14008 created Interagency Working Group within DOE to identify and provide federal support to coal, oil, gas and powerplant communities
 - April report on existing ways to provide grants, loans, and other assistance
 - Identified over \$45 billion currently available in existing federal programs
- Federal Legislation
 - Infrastructure Investment and Jobs Act and American Rescue Plan
 - ◆ Promote new opportunities in communities where coal plants are shutdown
 - Fission for the Future Act – S.3428 (Manchin and Barrasso)
 - ◆ Financial assistance priority for activities considering coal to nuclear
- State Initiatives
 - Colorado established Office to help coal communities move into new jobs
 - New Mexico enacted provisions for funding coal community assistance
 - Montana – Study bill for feasibility of SMRs to replace coal-fired boilers

Considerations for Replacing Coal Plants with SMRs

- Community
 - Community support for coal to nuclear transition
 - Ownership expectations for the site
 - Shared project engineering experience with coal and nuclear
- Economic
 - Inherent value of the land
 - Ability and desirability of CPP
- Infrastructure
 - Quality and value of grid connection
 - Transport infrastructure from barge, rail lines and heavy haul roads
 - Condition and understanding of site environmentally
 - Suitability of site to host a nuclear power plant

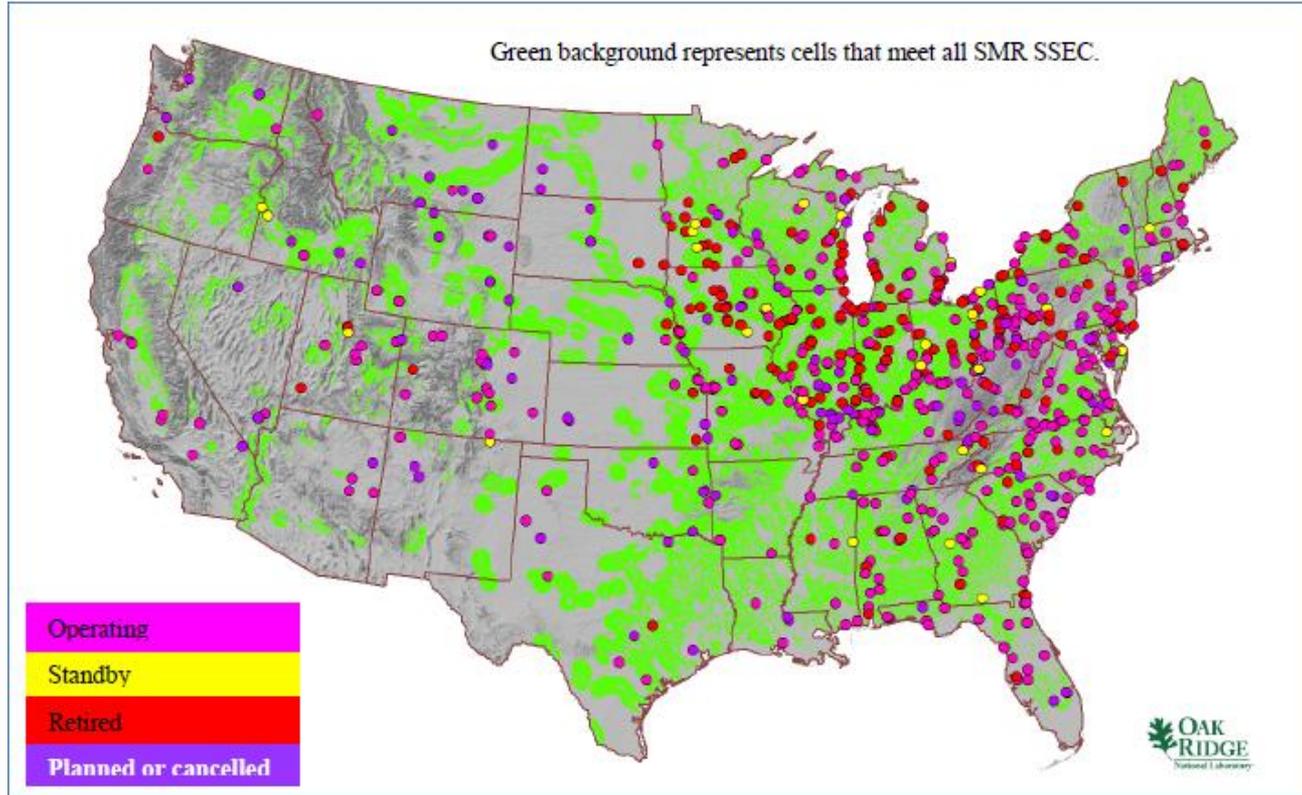
Colstrip to SMR

- Power plant
 - Two units - 778 MWe each
 - ~200 workers
 - Co-located mine
- Local community
 - Town of 2,200 people
 - Shutdown could reduce county revenue by ~10%
- Repurposing considerations
 - Complete decommissioning cost estimate - \$900M
 - Over 40 sq miles available for SMR
 - Reuse of power block valued at \$225M
 - Reuse of turbine could save 5.5% of cost of original plant



Source: INL, Transitioning Coal Power Plants to Nuclear Power

Coal Plants and SMR Suitability



Source: ORNL, [Evaluation of Suitability of Selected Set of Coal Plant Sites for Repowering with Small Modular Reactors](#), March 2013

QUESTIONS?



Backup / Content by Others

Types of Advanced Reactors

Range of sizes and features to meet diverse market needs

Micro Reactors
($< 20\text{MW}$)



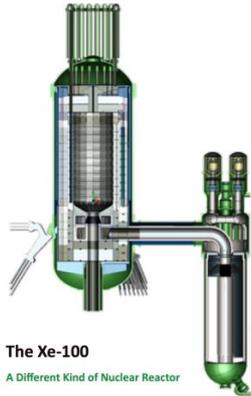
Oklo (shown)
Approximately a dozen in development

Light-water SMRs
 $< 300\text{MW}$



NuScale (shown)
GEH X-300
Holtec SMR-160

High Temp
Gas Reactors



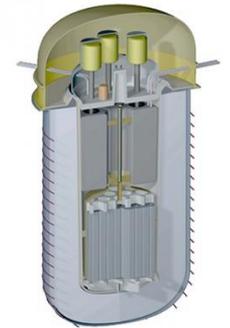
The Xe-100
A Different Kind of Nuclear Reactor
X-energy (shown)
Several in development

Liquid Metal Reactors



TerraPower Sodium (shown)
Several in development

Molten Salt Reactors



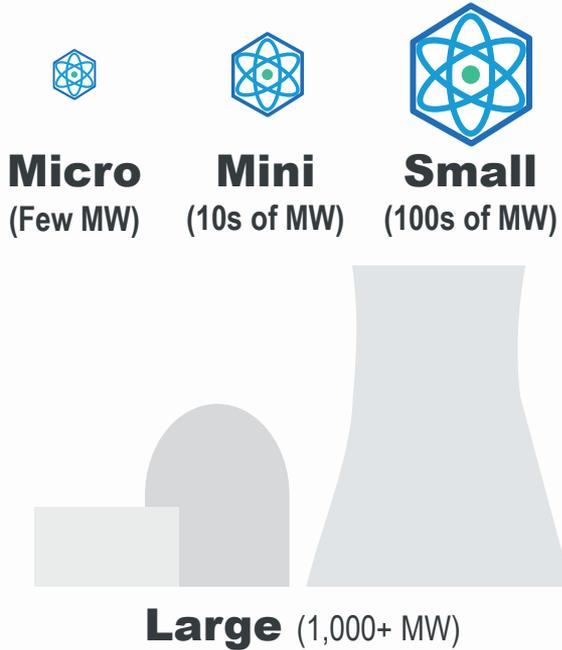
Terrestrial (shown)
Several in development

Non-Water Cooled

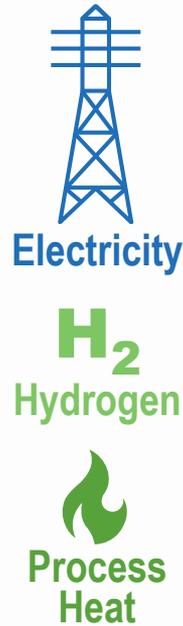
Most $< 300\text{MW}$, some as large as $1,000\text{MW}$

Advanced Nuclear Versatility

Spectrum of Sizes/Options



Variety of Outputs



Multitude of Uses



Affordable, Resilient and Flexible

SMALL

+

INHERENTLY
SAFE

=

**COST-
COMPETITIVE**

SIMPLER

- Inherent Safety
- Less Equipment
- Smaller Facility
- Regulatory Efficiency

READILY AVAILABLE EQUIPMENT

- Off-the-shelf Equipment
- Proven Performance

FACTORY- BUILT

- 60-80% of Equipment
- U.S. Supply Chain Growth

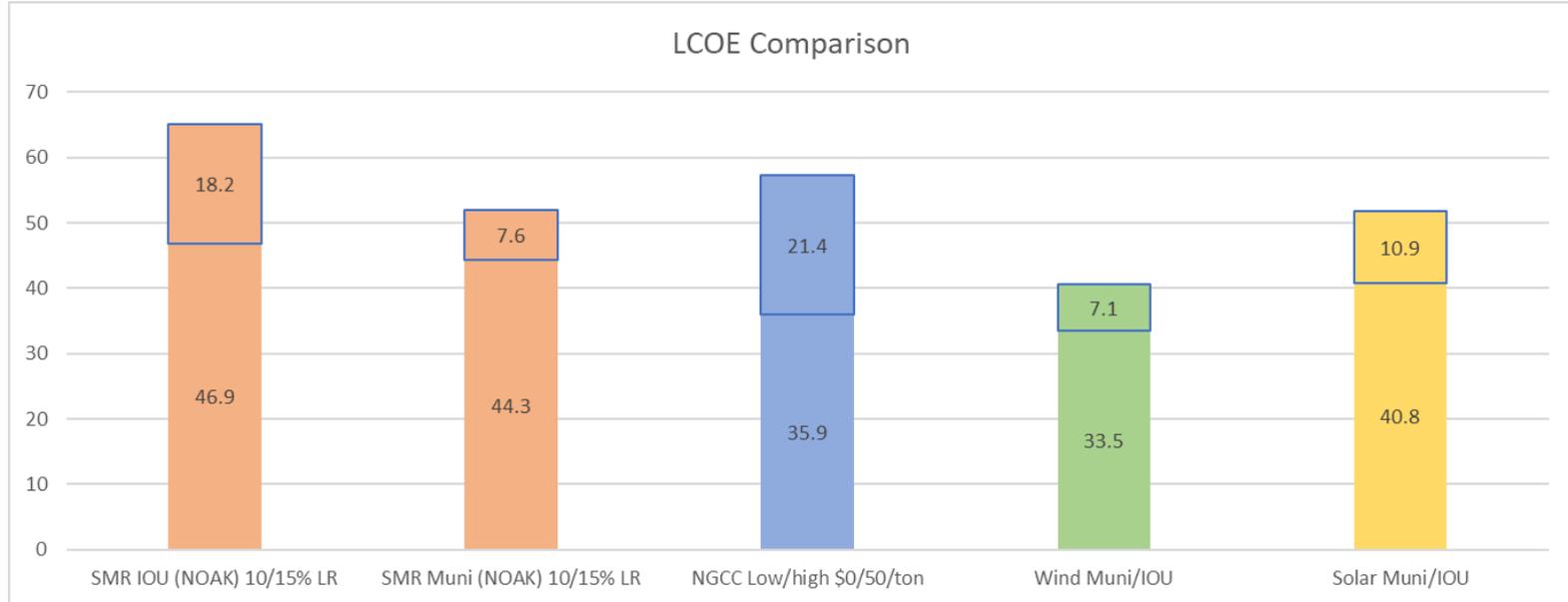
FASTER CONSTRUCTION

- Smaller Structures
- Assembly vs. Construction
- Modern Construction Methods

IMPROVED PERFORMANCE

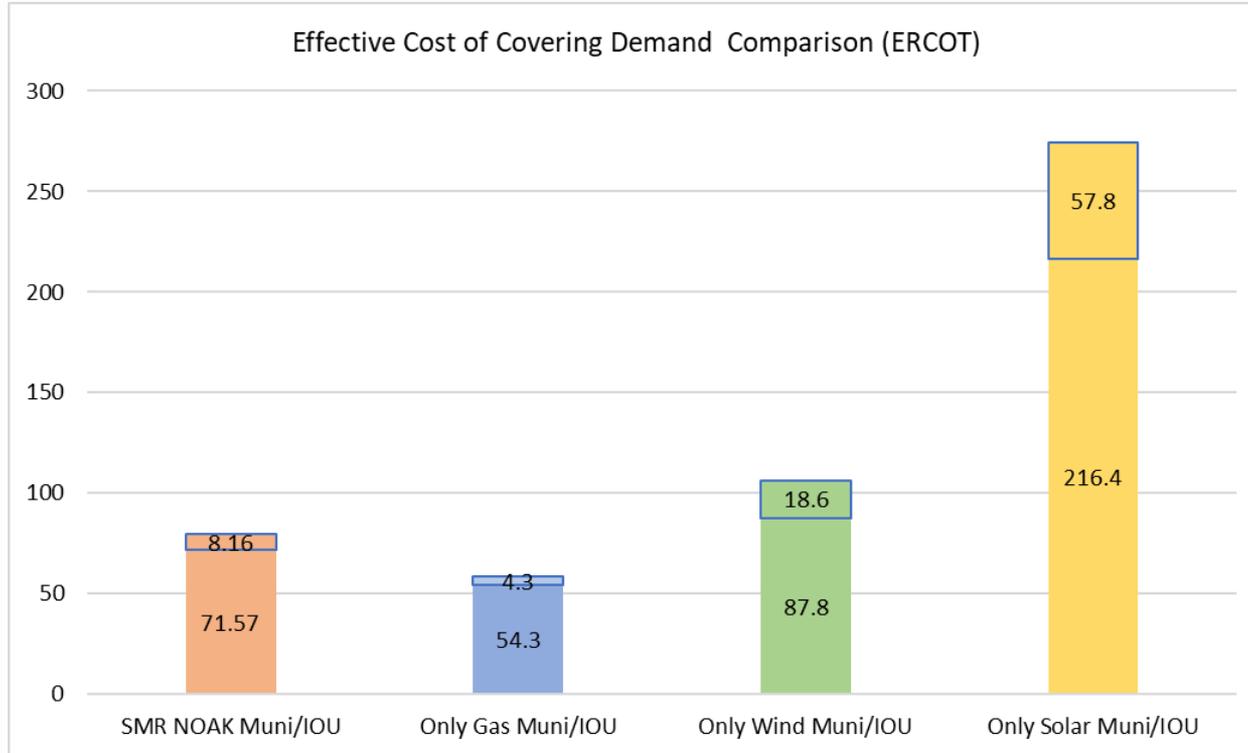
- Higher Thermal Efficiency
- Design and Construction Best Practices
- Operational Excellence

Advanced Reactor Cost Competitiveness in Electric Markets



From SMR Start Report on SMR Economics: <http://smrstart.org/wp-content/uploads/2021/03/SMR-Start-Economic-Analysis-2021-APPROVED-2021-03-22.pdf>

Considering system reliability needs makes nuclear even more affordable



Government Deployment Support

- Valuing all carbon-free sources of energy
- Federal Programs
 - Demonstrations
 - Tax Credits (e.g., Production)
 - Loan Guarantees
 - Federal Power Purchase Agreements
- State Programs
 - Tax incentives (e.g., property)
 - Advanced cost recovery
 - Infrastructure



<http://smrstart.org/wp-content/uploads/2017/07/SMR-Start-State-Options-for-New-Nuclear-Approved-2017-06-26.pdf>
<http://smrstart.org/policy-statement/>

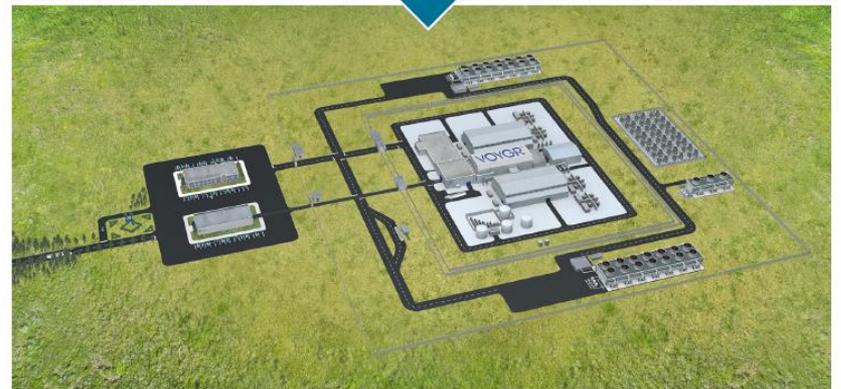
Current Status – Demonstrations by 2030

| Developer | Technology | Utility | Location | Size |
|---------------------------|----------------------|-----------------------|---------------------|-------------------------------|
| NuScale | Light Water SMR | UAMPS | Idaho | 6 @ 77MW |
| TerraPower & GE-Hitachi | Liquid Metal | Pacific Corp. | Wyoming | 345 - 500MW w/thermal storage |
| X-energy | High Temp. Gas | Energy Northwest | Washington | 4 @ 80MW |
| GEH BWR X-300 | Light Water SMR | OPG | Ontario, Canada | 300 MW |
| Oklo | Micro-reactor | Oklo | Idaho | 1.5 MW |
| Ultra Safe Nuclear | Micro-reactor | Global First / OPG | Chalk River, Canada | 5 MW |
| TBD | Micro Reactor | Department of Defense | Alaska | TBD |
| TBD (X-energy or BWXT) | Mobile Micro Reactor | Department of Defense | Idaho | TBD |

NuScale Coal Replacement Study

Repowering our Energy Communities

- A VOYGR™ power plant represents a century long investment in the host community
 - 1,200 construction jobs over three years
 - 270 operation jobs for 60 years
 - 677 induced/indirect jobs for 60 years
 - \$16M in local taxes, \$470M in local goods and services yearly
- Siting VOYGR power plants at retiring coal plants can equitably transition and repower communities clean energy
 - Retain and retrain coal/gas plant workforce
 - Re-use coal/gas plant infrastructure
 - Preserve local tax base and economy, worker and communities



TerraPower Coal Replacement - Wyoming

- A Natrium power plant represents a century long investment in the host community
 - 2,000 workers at construction peak
 - 250 people support day-to-day activities
 - Power 400,000 homes
- Kemmerer, WY selected as site for first Natrium
 - Near the Naughton Power Plant
 - “People across Wyoming welcomed us into their communities” Chris Levesque, CEO of TerraPower
 - Construction planned to begin in mid-2024



Source: TerraPower [Announcement](#)

TVA Coal to Nuclear Options

- TVA 2019 IRP signals phase out of coal-fired assets
 - Five coal-fired stations still operating
 - ◆ Two most suitable for an SMR
 - ◆ Three have siting challenges that would need to be addressed
 - Eight former coal plants
 - ◆ Six sites are most suitable for an SMR
 - ◆ One site transformed into a recreation area
 - ◆ One has siting challenges that would need to be addressed



Source: ORNL, [TVA Coal-Fired Plant for Potential Reactor Siting](#)

Coal to Nuclear Reference Reports

1. Scott Madden, [*Gone with the Steam*](#), October 2021
2. INL, *Transitioning Coal Power Plants to Nuclear Power*, December 2021
3. Good Energy Collective, [*Opportunities for Coal Communities through Nuclear*](#), December 2021
4. ORNL, [*Evaluation of Suitability of Selected Set of Coal Plant Sites for Repowering with Small Modular Reactors*](#), March 2013
5. ORNL, [*TVA Coal-Fired Plant Potential for Advanced Reactor Siting*](#), September 2021